PHAR LAP

386|DEBUG REFERENCE MANUAL

386|DOS-EXTENDER SDK

386|DEBUG Reference Manual

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Preface

This manual, *386 | DEBUG Reference Manual,* is the documentation for the Phar Lap symbolic debugger, 386 | DEBUG. It is written for MS-DOS programmers who are already familiar with developing and debugging real mode programs for the Intel 80x86 family of microprocessors, and is not intended as a teaching device; it is for reference and informational purposes only. It is organized in a way that we hope will make it easy for you to find the information you need, with the following chapters and appendices:

Chapter 1:	Introducing 386 | DEBUG.
Chapter 2:	Using 386 | DEBUG. This chapter includes information on the command line syntax, switches, formats, and operands; input and output; control of 386 | DEBUG; and protected-mode versus real-mode debugging.
Chapter 3:	386 | DEBUG Command Reference. This chapter provides an alphabetic listing of all 386 | DEBUG commands, their syntax, and a description of their uses and parameters.
Appendix A:	386 | DEBUG Command Line. This appendix provides a quick reference of the command line options, with a one-line summary of each command. It also provides a summary of expression formats.
Appendix B:	Error Messages. This appendix lists errors which can occur in 386 | DEBUG, their causes, and how to correct them.

If, after you read this book, you find that you have suggestions, improvements, or comments, please call us, write us or send us mail at:

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Manual Conventions

This manual relies on certain conventions to convey certain types of information. On the following pages, these are the conventions.

`Courier`	indicates command line, switch syntax and examples; this typeface was chosen for its close resemblance to screen display and to differentiate actual command lines from documentation.
`italics`	indicate items that must have a user-entered name or value entered in place of the items in italics.
[]	square brackets indicate that one or more of the enclosed items may be chosen. It is valid not to choose any of the items in the square brackets.

Commands with address range operands distinguish them as follows:

`range`	If both the start and end addresses must be specified;
`address``|`*`range`*	If the start address is required, but the end address is optional;
`[`*`range`*`]`	If both the start and end addresses are optional.

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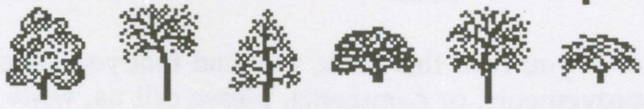


This manual was produced on a Macintosh IIcx, using MS-Word and MacDraw II. The examples illustrated in this manual were developed with 386 | DEBUG, version 3.0.

Chapter 1

Introducing 386 | DEBUG

386 | DEBUG is a symbolic machine language debugger for the Intel 80386 microprocessor family. It is used to debug programs written to execute in either the protected mode or the real mode of the 80386.

386 | DEBUG provides the same executing environment for protected mode programs as that provided by 386 | DOS-Extender. For real mode programs, 386 | DEBUG uses the standard MS-DOS environment.

386 | DEBUG commands have the same names and general syntax as those found in the SYMDEB utility supplied with MS-DOS. For both protected mode and real mode programs, 386 | DEBUG allows you to display and modify all 80386 registers, and supports disassembly of all 80386 instructions. Additional commands will display, change, move, and compare memory, set breakpoints and watchpoints in a program, and single-step instructions.

A source code debugger, 386 | SRCBug, is available as a separate product from Phar Lap Software.

Chapter 2

Using 386 | DEBUG

This chapter includes information on the basic command line syntax and detailed information on the command line switches, including any arguments each switch takes, in sections 2.1 and 2.2. Section 2.3 provides the information you need to know to start 386 | DEBUG running. Section 2.4 contains a description of command formats, operands, symbols, expressions, addresses, ranges, and expression operators. Section 2.5 documents how to load an alternate symbol table. Sections 2.6 and 2.7 describe display output, and input and output redirection. Section 2.8 discusses when 386 | DEBUG regains control from the application program, and section 2.9 discusses protected-mode versus real-mode debugging.

2.1 Command Line Syntax

The debugger is distributed as two files, 386DEBUG.EXE and 386DEBUG.EXP. Copy both files to the same directory on your hard disk.

The command line to run the debugger is 386DEBUG, followed by command line switches, then the name of the program to be debugged and any arguments to be passed to the application program:

```
386debug [debugswitches] programname [arguments]
```

The file RUN386.EXE (the 386 | DOS Extender) is required to be in one of the directories specified in the DOS environment variable "PATH". 386 | DEBUG will automatically start 386 | DOS–Extender and then load the program to be debugged. Because 386 | DEBUG searches the execution path for RUN386 just as DOS does, the same version of 386 | DOS–Extender is always used when debugging as when you run your program directly by typing:

```
run386 programname [arguments]
```

Some example debugger command lines are:

```
386debug myprog
386debug -maxreal 200h myprog
386debug pecho This is a protected mode program
```

Command line switches are used to override the default operation of 386 | DEBUG. The name of the program to be debugged can be supplied in full, or it can be given without a file extension. If no file extension is given, 386 | DEBUG first looks for a file with the extension .EXP (the default file name extension for a protected mode program). If no .EXP file exists, 386 | DEBUG then looks for a file with the extension .EXE (the default file name extension for a real mode program or a bound protected mode program).

386 | DEBUG supports debugging of three program file formats:

- EXP format, the default file format produced by 386|LINK for protected mode programs
- EXE format, the default file format produced by 386|LINK for real mode programs
- REX format, an alternative protected mode program format produced by 386|LINK.

In addition, 386 | DEBUG can be used to debug protected mode programs that are bound with the Phar Lap 386 | DOS-Extender. Please see the *386 | LINK Reference Manual* for a complete description of program file formats.

2.2 Command Line Switches

Command line switches change the default operation of 386 | DEBUG. By default, 386 | DEBUG:

- Assumes that a small memory model program is being debugged
- Ignores case when looking up program symbols
- Reads debugger command input from the system keyboard, and displays debugger output on the system screen.

Command line switches begin with a minus sign (-) character followed by the name of the switch. There are two forms of each switch name: a long form and a short form. Any argument to the switch must immediately follow the switch name, with a space as a separator. If conflicting switches are given on a command line, the last (rightmost) switch takes precedence.

Some 386 | DEBUG switches take a number as an argument. By default, the number is considered to be a decimal (base 10) number.

Hexadecimal (base 16) numbers may be specified by appending the character "h" or "H" to the number.

2.2.1 I/O Redirection Switches

The -COM1, -COM2, and -BAUD switches redirect 386 | DEBUG input and output from the system keyboard and display to a terminal connected to communications port 1 or 2 (on the back of the PC). This is useful when debugging application programs that make extensive use of the system display, since debugger output will not interfere with the application's display setup.

The -COM1 switch redirects debugger I/O to communications port 1. The -COM2 switch redirects I/O to communications port 2. If either of these switches is used without the -BAUD switch, the operations mode of the port is not modified. The DOS MODE command can be used to modify the operations mode of the port.

The -BAUD switch, in conjunction with -COM1 or -COM2, sets the port operations mode. -BAUD takes a single argument, which is the baud rate for the port.

Permissible values are:

110, 150, 300, 600, 1200, 2400, 4800, and 9600.

When the -BAUD switch is used, the rest of the port parameters are automatically set to 8 data bits, one stop bit, and no parity. Use of the

-BAUD switch thus overrides any previous MODE command entered from DOS.

Syntax:

```
-COM1
-COM2
-BAUD rate
```

Short Form:

```
-COM1
-COM2
-BAUD rate
```

Example:

```
386debug -com1 hello
386debug -com2 -baud 9600 hello
```

2.2.2 Case Sensitivity Switches

The -ONECASE and -TWOCASE switches select the case sensitivity of 386 | DEBUG. By default, 386 | DEBUG is insensitive to the case of all program symbols. For example, the symbols "my_sym", "my_SYM," and "MY_SYM" are all considered identical by default. The -TWOCASE switch enables case sensitivity in 386 | DEBUG. The -ONECASE switch disables case sensitivity. Since this is the default, this switch is redundant and is provided only for consistency.

The -TWOCASE switch should be used when debugging only if the -TWOCASE switch was used when the program was linked by 386 | LINK.

Syntax:

```
-ONECASE
-TWOCASE
```

Short Form:

```
-ONEC
-TWOC
```

Example:

```
386debug -twocase hello
```

2.2.3 Default Pointer Size Switches

The -SMALL, -COMPACT, -MEDIUM, and -LARGE switches specify the memory model of the program being debugged. This information is necessary for correct operation of the K and KA (stack trace) commands and the * indirection operator.

The -SMALL switch specifies a small model program (NEAR code and NEAR data pointers). The -COMPACT switch specifies a compact model program (NEAR code and FAR data pointers). The -MEDIUM switch specifies a medium model program (FAR code and NEAR data pointers). The -LARGE switch specifies a large model program (FAR code and FAR data pointers). The memory model for a program is determined when the program is compiled.

The default setting, if no pointer size switch is given, is a small model program. When debugging protected mode programs, small model should always be selected, as 386 | DOS-Extender currently requires small model for protected mode programs.

Syntax:

```
-SMALL
-COMPACT
-MEDIUM
-LARGE
```

Short Form:

```
-SMALL
-COMPACT
-MEDIUM
-LARGE
```

Example:

```
386debug -medium hello
386debug -large hello
```

2.2.4 Loading a Different Symbol Table Switch

The -SYMFILE switch loads the symbol table out of an .EXP file other than the program file initially loaded. This feature is useful for debugging program overlays or add–ins loaded by the application program during execution. When the -SYMFILE switch is used the symbol table for the primary program (the program initially loaded) is not available.

If no file extension is given, 386 | DEBUG automatically looks for files with the extension .EXP, .EXE, or .REX.

Please see section 2.5 for additional information about loading a symbol table from an alternate .EXP file.

Syntax:

```
-SYMFILE filename
```

Short Form:

```
-SF filename
```

Example:

```
386debug -sf display shell
```

2.2.5 386 | DOS-Extender Switches

It is not possible to enter 386 | DOS–Extender switches on the command line. All switches entered before the program name are processed by 386 | DEBUG, not 386 | DOS–Extender.

386 | DOS-Extender switches specified at program link time are automatically recognized by 386 | DEBUG. Although most 386 | DOS-Extender switches that apply to a specific application rather than to a particular machine or environment can be selected at link time, some switches can only be used at run time.

To use 386 | DOS-Extender switches that can only be given at run time, follow one of these methods:

- Place the switches in the environment variable, DOSX, which is always read by 386|DOS-Extender. After the debug session, remove the switches from the environment variable, so that the switches are not inadvertently left active when later running or debugging a different application. The following lines are an example of placing the switches in the environment variable:

  ```
  set dosx=-weitek on
  386debug -twocase hello
  set dosx=
  ```

- Configure the switches into 386|DEBUG itself, 386DEBUG.EXE, with the CFIG386 utility. By default, CFIG386 configures the switches into the stub loader on the front of 386DEBUG.EXE. When 386|DEBUG is running, the stub loader passes the configured switches to 386|DOS-Extender. After the debug session is complete, remove the configured switches or they will apply to all programs being debugged. Switches configured into 386|DEBUG apply only to programs being debugged, not to programs run directly with RUN386.EXE. The following lines are an example of configuring the switches into 386|DEBUG itself:

  ```
  cfig386 386debug -debug 1
  386debug -twocase hello
  cfig386 -clear 386debug
  ```

- Configure the switches directly into the 386|DOS-Extender file, RUN386.EXE, with the CFIG386 utility. Like the DOSX environment variable, switches configured directly into 386|DOS-Extender apply to all application programs, whether run with RUN386.EXE or debugged with 386DEBUG.EXE. The switches can be left in the file permanently, if desired. For example, if the 386|VMM virtual memory driver is always used when running or debugging applications, configure the -VMFILE switch into RUN386.EXE in the following manner:

  ```
  cfig386 run386 -vmfile vmmdrv
  386debug -twocase hello
  ```

2.3 Starting 386 | DEBUG

Programs to be debugged should be built with a symbol table containing all the public symbols in the program. This is done by using the -SYMBOLS switch on the command line when linking the program. The symbol table is appended to the end of the .EXP or .EXE file and is automatically loaded by 386 | DEBUG.

To begin debugging a program under the control of 386 | DEBUG, type a command line, as described in section 2.1. For example:

```
C>386debug hello
```

386 | DEBUG loads the program into memory and then displays a banner:

```
386|DEBUG 3.0--Copyright(C)1986-91 Phar Lap Software Inc.
[2000 bytes in the symbol table]

[80386 protected mode]

_
```

The first line of the banner gives the version number of 386 | DEBUG that is running. The second line gives the size in bytes of the program's symbol table. The fourth line indicates if the application is running in real mode or in protected mode. A real mode application uses the 80386 CPU as if it were an 8086/8088 CPU. In protected mode, the full power of the 80386 CPU is available to an application.

After the banner is displayed, 386 | DEBUG prints a minus sign (–), which means it is ready for you to type the first debugger command. 386 | DEBUG prints a minus sign any time one command has been completed and it is ready for another.

2.4 Command Formats

386 | DEBUG commands consist of a command name followed by command operands. Multiple operands are separated by spaces or tabs. Throughout this manual, optional command operands are enclosed in brackets ([ ]). If an optional command operand is not specified, a default value for the unspecified operand is assumed. Default operands for each command are specified with the command description.

2.4.1 Command Operands

Operands to 386 | DEBUG commands are comprised of the following basic elements:

- The name of a public symbol whose value is to be used by the command.
- The name of an 80386 register. Depending on the context of the command in which it is used, a register name can either specify a register to be acted upon (e.g., by the "change register" command) or identify the register contents as the value to be used by the command (e.g., display memory pointed to by EBX in the data segment).
- An absolute number. All absolute numbers are interpreted as hexadecimal (base 16) by 386|DEBUG.
- A character string surrounded by single quotes (e.g., 'ABC').
- The colon (:) character. This character is used to enter addresses in segment:offset form (e.g., FS:100).
- The plus (+) and minus (-) characters. These characters are used to combine absolute numbers, symbols, and register values in simple expressions.
- The asterisk (*) character. This character is used as an indirection operator in expressions.
- The left parenthesis (( ) and right parenthesis ( )) characters, used to parenthesize expressions.

Example:

```
-R EAX          Display contents of register EAX
-DB 100         Display memory at DS:100
-U main         Unassemble function "main"
-DD ptr_array   Display contents of "ptr_array" in doubleword
                format
-DB *bufptr     Display memory pointed to by variable
                "bufptr"
-DB FS:EBX      Display memory at FS:[EBX]
-F 0 50 'STK'   Fill memory with string, 'STK', from DS:0 to
                DS:50
-DB EBX+50      Display memory at DS:[EBX+50]
```

2.4.2 Symbols

When a debug session is started, 386 | DEBUG reads the symbol table at the end of the .EXP or .EXE file into memory. This symbol table contains an entry for each public symbol in the program. In assembly language programs, symbols are declared public with the PUBLIC directive. In C programs, all functions and global variables which have not been declared static are public symbols.

Each symbol is assigned a value which is equal to its address in memory. Whenever a symbol is used in a command, 386 | DEBUG substitutes the symbol value. Symbols can, therefore, be used wherever memory addresses are valid in debugger commands, and can also be combined in expressions. The X command lists all public symbols and their values, and can also be used to obtain the value of a specific symbol.

By default, 386 | DEBUG ignores case when looking up symbols. If the program has been linked with the -TWOCASE switch, use the 386 | DEBUG -TWOCASE switch to preserve upper and lower case for symbol lookup.

Symbol values in a real mode program are a full segment:offset address, where the offset is determined at program link time, and the segment paragraph address is determined when the program is loaded into memory. Symbol values in a protected mode program are only an offset in the single program segment constructed by 386 | LINK.

Since all absolute numbers are entered in hexadecimal, 386 | DEBUG assumes that the letters A-F are used to form numbers. A symbol will therefore only be recognized by 386 | DEBUG if it contains at least one character that is not in the set {0-9,A-F}. For example, if a program has a public symbol named "ABC", it is not possible to reference that symbol because 386 | DEBUG interprets it as a hexadecimal number and does not attempt to look it up in the symbol table.

Example:

```
-U chk_err  Unassemble error check routine
-DB buf+40  Display memory 64 bytes into buffer "buf"
```

2.4.3 Expressions

Command operands may be specified as:

- a symbol name
- an absolute number

☛ a register whose contents are the value to be used

☛ an expression which combines symbols, absolute numbers, and register contents, and is resolved by 386|DEBUG to a single value.

All arithmetic in expressions is performed with values treated as 32-bit unsigned numbers.

There are four expression operators. The addition (+) and subtraction (-) operators are the only arithmetic operators. The indirection (*) operator is used to perform one level of address indirection. The segment override (:) operator is used to separate the segment selector value from the offset in a full segment:offset address. The table below lists operator precedence, where operators of higher precedence are evaluated before operators of lower precedence. Operators of equal precedence are evaluated left to right. Please see the following table.

Operator	**Precedence**
* (indirection)	highest
+ -	
: (segment override)	lowest

Operator precedence may be overridden through the use of parentheses within the expression. Operations within parentheses are always evaluated before adjacent operations.

In the following example, the commands are sequential. Values shown on one line are used in the following lines.

Example:

```
-R EAX                                Display value of EAX
EAX=00000050

-R EBX                                Display value of EBX
EBX=00000100

-DB EBX                               Display memory at DS:00000100

-DB EBX-EAX                           Display memory at DS:000000B0

-DB CS:20+90-5                        Display memory at CS:000000AB
```

```
-X bufptr                          List symbol "bufptr"
bufptr = 00000400

-DD bufptr bufptr+4                Display pointer at "bufptr"
0014:00000400  00000800

-DB *bufptr                        Display memory pointed to by
                                   "bufptr" (at DS:00000800)

-DB *bufptr+100                    Display memory at DS:00000900

-DD ES:0 4
004C:00000000  00000A00

-DB CS:*(ES:0)                     Display memory at CS:00000A00
```

2.4.4 Addresses

Many 386 | DEBUG commands require the address of a memory location as a command operand. A memory address is specified with a segment selector value, and a byte offset within the segment. In protected mode, the segment selector is an index to an entry in the Local Descriptor Table (LDT) or the Global Descriptor Table (GDT) which describes the segment. In real mode, the segment selector is the paragraph base address of the segment in memory.

A 386 | DEBUG address operand can be specified as either a simple offset or a full segment:offset address. An offset is specified as a hexadecimal number, or by using a program symbol when debugging a protected mode program. If the expression specifies only an offset, a default segment is chosen based on the command. The U (unassemble), G (go), BP (set breakpoint), T (trace), TQ (trace quietly), P (procedure trace), and PQ (Ptrace quietly) commands all assume the segment pointed to by the CS register as the default segment. All other commands assume the segment pointed to by the DS register as the default.

A full segment:offset address can be specified in an expression in one of several ways:

- When debugging a real mode program, using a program symbol specifies the segment in which the symbol is defined.
- If the contents of an 80386 register is used in an expression, the default segment is the same as that assumed by the 80386 processor. Specifically, addresses formed with the contents of ESP, EBP, SP, or BP assume the SS segment, addresses formed with EIP or IP assume the CS segment, and all other registers assume the DS segment.
- A segment selector value can be explicitly specified using the : segment override operator.
- When the * indirection operator is used in an expression, the resulting address value includes a segment selector if a FAR pointer is retrieved from memory. If a NEAR pointer is retrieved, the address value is only an offset.

The expression operators and the ways in which they can be used to create memory addresses are described in more detail in section 2.4.6.

Example:

```
-DB 100         Display memory at DS:100
-G =100         Go (start executing) at location CS:100
-DB EBX         Display memory at DS:[EBX]
-DB ESP         Display memory at SS:[ESP] (top of stack)
-U *ESP         Unassemble at procedure return address
                on top of stack
-G =fatal_err   Go (start executing) at routine "fatal_err"
-DB buf         Display contents of buffer "buf"
-DB buf+EBX     Display memory EBX bytes into "buf"
-DB FS:EBP+20   Display memory at FS:[EBP+20]
-DB 3C:0        Display memory at 003C:00000000
```

2.4.5 Ranges

Several commands operate on memory locations within a range of addresses. A range is defined by its start and end addresses. Most commands that require a range permit you to specify only the start address of the range, and assume a default end address (typically, a specific number of bytes past the start address). In many cases, the start address of the range is also optional, and the command will supply a default value one byte past the end of the range specified the last time the command was used, or zero if the command has never been used in the debugging session.

The command descriptions use the following notation with commands that take an address range as operands:

range	If both the start and end addresses must be specified;
address|*range*	If the start address is required, but the end address is optional;
[*range*]	If both the start and end addresses are optional.

When specifying an address range, a full segment:offset address may only be specified for the start address. The end address for a range is required to be in the same segment as the start address, and a segment override for the end address is therefore prohibited.

Example:

```
-DB buf buf+100    Display the first 256 bytes of "buf"
-DB 100 200        Display memory from DS:100 to DS:200
-DB CS:10 20       Display memory from CS:10 to CS:20
-DB 0              Display memory from DS:0 to DS:7F
                   (128 bytes)
-DB                Display memory from DS:80 (one past
                   the end of the last DB command) to
                   DS:FF
```

2.4.6 Expression Operators

Addition and Subtraction Operators

The + and - operators are used to perform arithmetic addition or subtraction of two operands. When a memory address is being formed, at most one operand can be a full segment:offset address; the other operand must be a simple offset (an absolute number). The only exception is when a symbol is combined with the contents of a register. In that case, the specified segment selectors may differ, and the segment in which the symbol is defined takes precedence over the default segment assumed for the register.

Example:

```
-DB 50+70-10     Display memory at DS:B0
-T 3+5           Trace 8 instructions
-DB EBP+10       Display memory at SS:10[EBP]
-DB buf+BP       Display memory BP bytes into "buf"
```

Segment Override Operator

The : segment override operator is used to override the segment selector part of a memory address. The segment selector value to the left of the : operator replaces the segment selector specified by the expression to the right of the : operator. This operator is useful when the default segment selected by 386 | DEBUG for a command is not the desired segment.

Example:

```
-DB CS:20        Display memory in the code segment
-DB FS:EBP       Display memory at FS:[EBP]
-G =4C:10        Start execution at 004C:10
```

Indirection Operator

The indirection operator (*) is used to perform one level of address indirection through a pointer stored in memory. Using this operator, a pointer stored in memory can be used to directly access the memory locations to which it points, instead of having to enter two commands, one dumping out the pointer, and the second using the hexadecimal value of the pointer obtained from the first command.

The * operator uses the memory model of the program to decide whether to pick up a NEAR (offset only) or a FAR (segment:offset) pointer out of memory. The program's memory model is specified with the -SMALL, -COMPACT, -MEDIUM, or -LARGE command line switches, or with the MS, MC, MM, or ML debugger commands.

For memory models (such as COMPACT or MEDIUM) which use one type of pointer for data and the other type for code, the * operator decides if it is picking up a code or a data pointer based on whether the default segment for the command is the code or data segment. For example, if the command is U (unassemble), the * operator will pick up a code pointer; if the command is DB (display memory), the * operator will pick up a data pointer. The default segment for each command is specified in section 2.4.4.

The operand of the * operator is the memory address at which the pointer is stored. As usual, the address of the pointer can be specified as either a full segment:offset, or as an offset only. If only an offset is specified, the default segment for 386 | DEBUG command is used to locate the segment in which the pointer is stored.

The pointer address retrieved from memory completely replaces the address used to retrieve the pointer. If a NEAR pointer is retrieved, the resulting address specifies an offset value only, regardless of whether the memory address at which the pointer is stored specifies a segment selector.

Example:

```
-DB *bufptr                 Display memory pointed to by
                            variable "bufptr"
-S *bufp *bufp+400 FF       Search array pointed to by
                            "bufp" for bytes with values FF
-U *(EBP+4)                 Unassemble instructions at
                            return address from the current
                            routine
-DD FS:10 14                Display NEAR pointer value
0054:00000010  000002A0
-DB *(FS:10)                Display memory at DS:2A0
-DB FS:*(FS:10)             Display memory at FS:2A0
```

2.5 Loading Alternate Symbol Tables

The -SYMFILE switch loads the symbol table out of an .EXP file other than the program file initially loaded. The syntax of the switch is:

```
-SYMFILE filename
```

The *filename* parameter specifies the executable file from which to load the symbol table. Use this switch for debugging program overlays or add-in drivers loaded by the main application program during execution. When this switch is used, the symbol table for the primary program (the program initially loaded) is not available.

Programs that load in add-in drivers or overlays at runtime often allocate separate code and data segments (i.e., they don't load the add-in into segments 000Ch and 0014h). Since the selectors for these additional code segments and data segments are not known until runtime, you must tell 386 | DEBUG which segment selectors are used for the symbol table loaded with -SYMFILE.

Use the XR command (see section 3.30) to tell 386 | DEBUG which segments are in the symbol table. The XR command must be given after the add-in driver or overlay is loaded.

For example, suppose your main program, SHELL.EXP, loads a secondary program called DISPLAY.EXP. To debug DISPLAY.EXP symbolically, follow these steps:

☛ Use the -SYMFILE switch to load the symbol table for DISPLAY.EXP rather than SHELL.EXP:

```
386debug -symfile display shell
```

☛ Set a breakpoint in shell (the main program) following the routine that loads DISPLAY.EXP. Since the symbol table for shell is not loaded, you have to use hex addresses obtained from the map file for shell. (Alternatively, you could assemble an INT 3 instruction into your shell program to pass control to 386|DEBUG). Let's assume the load routine for shell is at hex address 8F90. Then you can get control after DISPLAY.EXP is loaded with these commands:

```
-g 8F90
-g *esp
```

☛ Use the XR command to tell 386|DEBUG which segments are used for DISPLAY.EXP, so it uses those segments (rather than 000Ch and 0014h) for symbols. SHELL.EXP could print out the segment selectors, or you could use the DL command to examine the LDT before and after DISPLAY.EXP is loaded to see which segment selectors are allocated. Let's assume the code segment for display is 007Ch, and the data segment is 0084h. Use the XR command to relocate the symbol table to these selectors:

```
-xr C 7C
-xr 14 84
```

2.6 Controlling 386 | DEBUG Display Output

Some 386 | DEBUG commands can potentially generate a very large amount of output to the display (for example, displaying a huge block of memory). When this occurs, it is possible to stop (temporarily) output and prevent desired information from scrolling off the top, and to cancel output to the display and return to 386 | DEBUG command prompt.

The CTRL/S character (hold down the CTRL key while striking the S key) temporarily stops output to the display. After examining the information on the display, any key can be pressed to cause 386 | DEBUG to resume output to the display.

The CTRL/C character cancels the output for a command and returns to the 386 | DEBUG command prompt.

2.7 Input and Output Redirection

2.7.1 I/O Redirection to a Communications Port

386 | DEBUG supports redirection of keyboard and display I/O to a terminal connected to communications port 1 or 2 of the PC. This feature is useful for debugging I/O-intensive applications that make heavy use of the system display and/or the keyboard.

I/O can be redirected to one of the communications ports either by command line switches when the debugging session is started, or by debugger commands entered during the debug session. If the -COM1 or

-COM2 command line switch is given, then I/O, including 386 | DEBUG startup banner, is redirected to the specified communications port. If the -BAUD switch is also used, then the port will be reprogrammed to use the specified baud rate, 8 data bits, one stop bit, and no parity. If the -BAUD switch is not given, then the communications port parameters are not modified. This allows arbitrary parameters to be specified with the DOS MODE command before starting the debug session.

At any point during a debug session, I/O can be redirected to a communications port with the COM1 or COM2 commands. These commands do not modify the port parameters; they just redirect 386 | DEBUG I/O. When entering commands at a remote terminal, the CON command can be used to redirect I/O back to the system console.

When I/O is redirected to a communications port, CTRL/C usage is slightly modified. While the application program is running and making DOS calls, a CTRL/C typed at the remote terminal will be ignored, and a CTRL/C typed at the system keyboard will cause 386 | DEBUG to gain control (with I/O still redirected to the communications port). When 386 | DEBUG has control, a CTRL/C typed at the remote terminal causes output (such as a long dump) to be terminated. When 386 | DEBUG has control and is waiting for a command, a CTRL/C typed at the system keyboard redirects I/O to the system console. This last feature is useful if you are unable to enter commands at a remote terminal because of an incorrect baud rate or similar problem. Please see section 2.8.5 for more information on CTRL/C processing.

When I/O is redirected to a communications port, there is no type-ahead feature. Characters typed when 386 | DEBUG is not waiting for input will be ignored.

2.7.2 I/O Redirection to Disk Files

Normally, 386 | DEBUG commands are typed at the keyboard, and output is printed on the display. However, it is possible both to read commands from a script file on the disk, and to redirect output to a log file on the disk.

Command input redirection is specified on the command line by typing the less than character (<), followed by the name of the file containing the commands. Blank lines in the input file are ignored, and the special character * may be used at the beginning of a line to denote a comment (a line to be ignored by 386 | DEBUG). Commands are processed up to the first quit (Q) command in the file, or to the end of the file, whichever comes first. If there is no quit command in the file, 386 | DEBUG quits when the end of the file is reached.

Output redirection is specified on the command line by typing the greater than character (>), followed by the name of the file to which the output is written.

Note that although it is possible to redirect output without redirecting input, the results can be confusing if you do so. When output is redirected, **all** characters which would be displayed on the screen are instead written to the output file. This includes keystrokes which are normally echoed on the screen. Thus, it is impossible to see what is being typed on the keyboard if input is not redirected while output is redirected.

Example:

To type commands at the keyboard and to print debugger output on the display:

```
386debug hello
```

To read commands from the file "script" and to print debugger output on the display:

```
386debug hello <script
```

To read commands from the file "script" and to write debugger output to the file "log":

```
386debug hello <script >log
```

2.8 Regaining Control

386 | DEBUG commands may be entered only when 386 | DEBUG has control and has issued the dash (-) as a prompt. There are a variety of ways to regain control in 386 | DEBUG when the application program is executing. These methods are discussed in the sections below. Whenever 386 | DEBUG regains control, it will print out the reason it regained control and the current state of the processor.

2.8.1 Program Breakpoints and Instruction Tracing

Program breakpoints cause 386 | DEBUG to stop execution of the application immediately before it executes the instruction at a specified breakpoint address. After gaining control, 386 | DEBUG displays the 80386 registers and prompts for a command. Breakpoints allow a program to execute up to the point where an error is suspected, in order to examine memory and registers for the cause of the error.

There are two kinds of breakpoints: temporary breakpoints and permanent breakpoints. Temporary breakpoints are set with the go (G) command and are always cleared when 386 | DEBUG gains control again for any reason. For a temporary breakpoint to remain in effect, it must be specified each time the G command is entered. Permanent breakpoints are set with the BP command, and remain in effect until cleared with the BC command or disabled with the BD command. Permanent breakpoints are useful, for example, to set a breakpoint on a critical function that may be called many times. Temporary breakpoints are useful when stepping through a program, since there is no need to clear temporary breakpoints.

Breakpoints must be set on instruction boundaries. If breakpoints are placed in the middle of an instruction, they will not be recognized and 386 | DEBUG will not gain control. The unassemble (U) command can be used to determine the address of a specific instruction.

A feature related to breakpoints is the trace (T) command. This command executes a single instruction in the program under test and then returns control to 386 | DEBUG. It has the same effect as using the G command to set a breakpoint on the next instruction. This feature is useful for stepping through a sequence of instructions in which a bug is suspected.

Example:

```
-BP printf       Set a permanent breakpoint at print routine
-G fatal_err     Set a temporary breakpoint at fatal error
                 routine and execute from current address
-G 55 7B         Set temporary breakpoints at CS:55 and CS:7B
                 and execute from current address
-T 5             Trace five instructions
```

2.8.2 Data Watchpoints

Data watchpoints cause 386 | DEBUG to stop execution of the application immediately after execution of an instruction that reads or writes a specific memory location. When a data watchpoint occurs, 386 | DEBUG displays the memory location that was accessed and the current register contents, and then prompts for a command. Data watchpoints can be useful for finding bugs which cause code or data locations in the program to be corrupted.

Watchpoints are set with the WP command. When a watchpoint is set, both the address of the location to be watched and the size of the expected access (one, two, or four bytes) must be specified. If the wrong data size is used, the hardware will not detect an access to the memory location. In addition, watchpoints can be set to occur on a write access only, or for either a read or a write access to the memory location. By default, WP sets a write only watchpoint. To set a read/write watchpoint, the character r must be the last parameter given to the WP command.

Example:

```
-WP bufp 4       Set watchpoint to occur when pointer variable
                 "bufp" is modified
-WP errf 2 r     Set watchpoint to occur when an error flag is
                 either read or written
-WP main+20 1    Set watchpoint to occur when code in the
                 "main" routine gets wiped out
```

2.8.3 Processor Exceptions

The 80386 processor can detect certain classes of program errors. When one of these errors occurs, the CPU will generate a processor exception.

Interrupt numbers 00 through 20 (hex) are reserved by Intel for processor exceptions. 386 | DEBUG installs handlers for most of the 80386 processor exceptions and will therefore gain control whenever an exception occurs. The 80386 processor exceptions are:

Number (hex)	Error
00	Divide overflow
01	Debugger trace and breakpoints
02	External non-maskable interrupt
03	INT 3 debugger breakpoint
04	Overflow (INTO instruction)
05	BOUND instruction (array bounds checking)
06	Illegal instruction opcode (typically caused by a program jumping into data)
07	Numeric coprocessor not available
08	Double fault
09	Coprocessor segment overrun (coprocessor attempts to access data past the end of a segment)
0A	Invalid TSS (task state segment used in task switch invalid)
0B	Segment not present (attempt to use segment descriptor marked not present in GDT or LDT)
0C	Stack fault (segment limit violation on operations that use the SS segment register)
0D	General protection violation
0E	Page fault (page not present)

2.8.4 Program Termination

When the program being tested terminates, 386 | DEBUG gains control. The register contents are not displayed, as 386 | DEBUG does not know the location from which the DOS exit call was made or the register values at the time of the call. (386 | DEBUG does not gain control until after the DOS program termination code has executed.) Instead, the exit value passed to DOS by the program is displayed.

After the program terminates, any execution command such as go (G), trace (T), or procedure trace (P) should not be executed. This restriction exists because the memory allocated to the program has already been freed, and thus there is no valid instruction or stack space. Using one of these switches after program termination will generate the message "Application program not in memory".

2.8.5 CTRL/C

Programs that make DOS calls may be interrupted by typing CTRL/C. When DOS gains control and sees a CTRL/C in the keyboard buffer, it issues interrupt number 23 (hex), which is also handled by 386 | DEBUG. This is useful for interrupting programs caught in an infinite loop.

There are some differences in the behavior of CTRL/C between debugging real mode programs and protected mode programs. If the program is executing in protected mode when it issues the DOS call which results in a CTRL/C interrupt, then the register display will show the register contents at the time the DOS call is issued. After gaining control via a CTRL/C from a protected mode program, 386 | DEBUG will not permit any register contents to be altered, because when control is passed back to the program, the DOS call actually completes. Commands that do not alter register values, however, can be used without restriction.

When a real mode program is interrupted with CTRL/C, the register display shows the register contents at the time DOS issues the CTRL/C interrupt. 386 | DEBUG permits registers to be modified, though this is not advised because it affects how DOS finishes processing the system call which is interrupted. The trace (T) command causes 386 | DEBUG to trace instructions in DOS rather than in the application program (unlike protected mode programs).

2.9 Protected Mode versus Real Mode Debugging

386 | DEBUG can be used to debug both real mode and protected mode programs. Real mode programs have a default file extension of .EXE, and protected mode programs have a default file extension of .EXP. The banner displayed by 386 | DEBUG tells whether the program runs in protected mode or real mode.

386 | DEBUG provides the same basic commands for debugging in either mode. The only commands that are not available when debugging real mode programs are the commands to display protected mode system tables: DG, DL, and DI. All other commands operate identically in either mode.

The main difference between debugging real mode and protected mode programs is in the values used for segment selectors. For protected mode programs, segment selectors are an index into the LDT (local descriptor table), which can be displayed with the DL command, and therefore tend to be small numbers, such as hexadecimal "0C" for the code segment and hexadecimal "14" for the data segment. For real mode programs, segment selector values are the paragraph base address of the segment and thus tend to be large numbers, such as hexadecimal "3D69". For a more detailed description of the differences between real mode and protected mode programs, please see the *386 | ASM Reference Manual.*

For protected mode programs, symbol values are 32-bit offsets in the single program segment that is pointed to by both CS and DS. For real mode programs, symbol values are in segment:offset form, where the segment value is the 16-bit paragraph base address in memory of the segment in which the symbol is located, and the offset value is a 16-bit offset within the segment.

Examples of protected mode commands:

```
DB buf       Display data in buffer "buf"
DB CS:100    Display data at offset 100 in segment pointed to
             by CS
DB C:100     Display data at offset 100 in segment whose
             selector value is "0C"
```

Examples of real mode commands:

```
DB buf       Display data in buffer "buf"
DB CS:100    Display data at offset 100 in segment pointed to
             by CS
DB 3D69:100 Display data at offset 100 in segment whose
             selector value (paragraph address) is 3D69
```

386 | DEBUG Command Reference

This chapter provides a detailed reference guide to 386 | DEBUG commands. For each command, the following information is given:

- The syntax of the command. Optional operands are in brackets ([ ]);
- A description of the command;
- Some example usages of the command.

3.1 BC, BD, BE, BL, and BP Commands — Breakpoint Control

Syntax:

```
BC breakpts
BC *
BD breakpts
BD *
BE breakpts
BE *
BL
BP address
```

Description:

The breakpoint control commands set, clear, enable, disable, and list breakpoints. Breakpoints must be set on instruction boundaries. They cause 386 | DEBUG to gain control before the instruction is executed.

The BC command clears breakpoints. It takes as an argument either a list of breakpoint numbers, or the special character *, which is a shorthand for all breakpoints. Once a breakpoint has been cleared, it is no longer listed by the BL command and cannot be enabled with the BE command. If the breakpoint is needed again after being cleared, it must be reset with the BP command.

The BD and BE commands disable and enable breakpoints. They take as an argument either a list of breakpoint numbers, or the special character *, which is a shorthand for all breakpoints. The BD command is used to temporarily disable breakpoints that are not desired to be active. The BE command is used to enable breakpoints previously disabled with the BD command.

The BL command lists breakpoints set with the BP command. Each breakpoint is identified by a number assigned by 386 | DEBUG. For each breakpoint, the BL command lists its breakpoint number, the address of the instruction on which the breakpoint is set, and the internal mechanism that 386 | DEBUG used to set the breakpoint (either "Debug reg" if one of the 80386 hardware registers was used, or "INT 3", if the 1-byte debug interrupt instruction was used). In addition, if the breakpoint has been disabled, the BL command prints "***disabled***" following the breakpoint information.

The BP command sets breakpoints. The command operand is the address of the instruction on which to set the breakpoint. Breakpoints set with the BP command may be either enabled (on) or disabled (off). When the breakpoint is first set with the BP command, it is always enabled.

Example:

```
-BP main
-BP err_chk
-BP main+9
-BL
0 MAIN mechanism=Debug reg
1 ERR_CHK mechanism=Debug reg
2 MAIN+09 mechanism=Debug reg
-BD 0 2
-BL
0 MAIN mechanism=Debug reg  ***disabled***
1 ERR_CHK mechanism=Debug reg
2 MAIN+09 mechanism=Debug reg  ***disabled***
```

```
-BE *
-BC 1
-BL
0 MAIN mechanism=Debug reg
2 MAIN+09 mechanism=Debug reg
```

3.2 C Command — Compare Memory

Syntax:

```
C range address
```

Description:

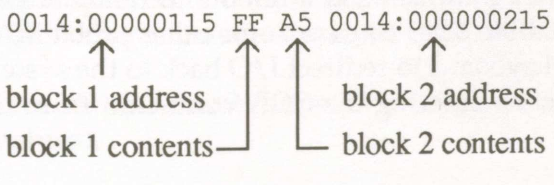
The compare memory command compares two blocks of memory to determine if they are equal. Any differences between the two blocks are printed on the screen. The C command has three operands. The first two operands specify the address range of the first block to be compared. The last operand is the start address of the second block of memory. No end address for the second block may be specified, since 386 | DEBUG always assumes the second block is the same size as the first block. If no segment selector is specified for either the first or second block, the value in the DS register is used by default.

Example:

The command

```
-C 100 1FF 200
```

compares memory locations 100 through 1FF, inclusive, on a byte-by-byte basis with memory locations 200 through 2FF. For each pair of bytes that differ, 386 | DEBUG displays a line containing the address and value of each byte. It is formatted as follows:



```
0014:00000115 FF A5 0014:000000215
```

The command

```
    -C  buf1  buf1+100  buf2
```

compares the first 256 bytes of buffers "buf1" and "buf2".

3.3 COM1, COM2, and CON Commands — I/O Redirection

Syntax:

```
COM1
COM2
CON
```

Description:

The I/O redirection commands redirect 386 | DEBUG I/O between the system console and a terminal connected to communications port 1 or 2 on the PC. The COM1 command is entered at the system keyboard to redirect I/O to communications port 1. The COM2 command is entered at the system keyboard to redirect I/O to communications port 2. The CON command is entered at the remote terminal connected to a communications port to redirect I/O back to the system console.

Note that the communications port parameters are not modified by the COM1 or COM2 commands. The port parameters can be set explicitly by the DOS MODE command before starting the debugging session. Alternatively, the -BAUD command line switch can be used in conjunction with the -COM1 or -COM2 command line switch to reprogram the communications port to the specified baud rate, 8 data bits, one stop bit, and no parity. I/O can then be redirected back and forth with the CON and COM1 or COM2 commands without changing the port parameters.

If you are unable to enter commands at a remote terminal after redirecting I/O because of incompatible baud rates or some other problem, type a CTRL/C at the system keyboard to redirect I/O back to the system console. This has the same effect as entering the CON command from the remote terminal.

Example:

To redirect I/O to communications port 1 at the main system:

```
-COM1
```

To redirect I/O from a remote terminal back to the console at a remote system:

```
-CON
```

3.4 D, DA, DB, DD, and DW Commands — Display Memory

Syntax:

```
D  [range]
DA [range]
DB [range]
DD [range]
DW [range]
```

Description:

The display memory commands display memory locations on the screen. They take an optional range operand, which specifies the block of memory to be displayed. If no start address is specified, memory is displayed at the location following the last byte displayed with the most recent display command. If no end address is specified, 128 bytes of memory are displayed.

The DA command displays data in ASCII format only. It displays data up to the first zero byte encountered, or up to the endpoint of the specified range if no zero byte is encountered.

The DB command formats the display as individual bytes. The data bytes are displayed in both hexadecimal and ASCII format. Non-printable ASCII characters are displayed as a period (.).

The DD command formats the display as hexadecimal doublewords (32-bit values).

The DW command formats the display as hexadecimal words (16-bit values). This is useful because the DB command shows the bytes of word values in reverse order, due to the byte ordering imposed on values by the 80386.

The D command is simply a shorthand for the most recently used display command. For example, if a DD command is given followed by a D command, the display is formatted as doublewords.

If the previous display command was a floating point display (DF, DS, DQ or DT) the D command repeats the floating point display format.

If no segment is specified with the address, the display memory commands default to the segment pointed to by DS.

Example:

```
-DB buf  buf+F
0014:00000100  45 72 72 6F 72 00 01 02-12 64 00 00 00 00 00 00 Error....d......

-DW buf  buf+F
0014:00000100  7245 6F72 0072 0201 6412 0000 0000 0000

-DD buf  buf+F
0014:00000100  6F727245 02010072 00006412 00000000

-DA buf  buf+F
0014:00000100  Error

-DW CS:0 F
000C:00000000  139A 0000 0005 0200 A5A5 0090 001A 0000
```

3.5 DF, DS, DQ, and DT Commands — Display Memory as Floating Point

Syntax:

```
DF [range]
DS [range]
DQ [range]
DT [range]
```

Description:

The DF, DS, DQ, and DT commands display memory as IEEE (the floating point format used by the 80387, the Weitek 3167/4167, and the Cyrix EMC87 coprocessors) floating point numbers. They take an optional range operand, which specifies the block of memory to be displayed. If no start address is specified, memory is displayed at the location following the last byte displayed with the most recent display command. If no end address is specified, a single floating point number is displayed.

The DF and DS commands display 4-byte (short) floating point numbers. These are values declared with the "float" data type in C programs, or with the DD directive in assembly language code.

The DQ command displays 8-byte (quadword) floating point numbers. These are values declared with the "double" data type in C programs, or with the DQ directive in assembly language code.

The DT command displays ten-byte floating point numbers. These are values declared with the DT directive in assembly language code.

Please see the D command, section 3.5, to repeat any display format.

Example:

```
-ds flt_const flt_const+c
0014:00002440  B4 C8 16 40    2.3559999E+00
0014:00002444  D0 0F 49 40    3.1415901E+00
0014:00002448  AC 8B 5B 3C    1.3400000E-02
-df
0014:0000244C  AE C7 10 44    5.7912000E+02
```

```
-dq dbl_const dbl_const+10
0014:00002410  6E 86 1B F0 F9 21 09 40   3.1415900000000000E+00
0014:00002418  74 4E 0D E4 B8 BC 50 44   1.2349871000000000E+21

-dt tbyte_const
0014:000023E0  C2 F5 28 5C 8F C2 F5 CA 03 40   2.5370000000000000E+01
-dt
0014:000023EA  1E 72 33 DC 80 CF 0F C9 00 40   3.1415900000000000E+00
-dt
0014:000023F4  00 00 00 00 00 00 00 80 FF 3F   1.0000000000000000E+00
```

3.6 DG, DI, and DL Commands — Display System Tables

Syntax:

```
DG [range]
DI [range]
DL [range]
```

Description:

The DG, DI, and DL commands display the system GDT (global descriptor table), IDT (interrupt descriptor table), and LDT (local descriptor table), respectively. Each command takes two optional operands: DI takes starting and ending interrupt numbers, and DG and DL take starting and ending segment selector numbers.

If no operand is given, 16 table entries are displayed, beginning with one past the last entry displayed the last time the command was used. If only a start operand is given, 16 entries are displayed, beginning with the one at the specified operand. If both a start and an end operand are given, all entries between the start and the end operand, inclusive, are displayed.

The GDT maps segments used by 386 | DOS-Extender, and the LDT maps segments used by the application program and 386 | DEBUG. Specific segment assignments are described in detail in the *386 | DOS-Extender Reference Manual*. For each entry in the GDT or LDT, the DG or DL command displays the following information. All values are given in hexadecimal.

- The segment selector used to access the segment;
- The segment linear base address;
- The segment limit (in bytes);
- The flags byte (access rights byte) in the segment descriptor;
- The segment use type — USE16 for a 16-bit segment, or USE32 for a 32-bit segment.

For a complete description of segment descriptors, including the bit definitions of the flags byte, please see the Intel manual, *80386 Programmer's Reference Manual.*

The IDT contains descriptors which point to the interrupt service routines for each of the 256 possible interrupts supported by the 80386. For each entry in the IDT, the DI command displays the following information. All values are given in hexadecimal.

- The interrupt number that corresponds to the IDT entry (this is the same as the index of the entry in the table);
- The gate type;
- The segment selector and offset of the handler routine for the interrupt;
- The flags byte in the descriptor;
- The type;
- The descriptor privilege level.

The DG, DI, and DL commands are not available when debugging real mode programs.

Example:

```
-DG 0 8
#0000 Segment not present
#0008 Base=00025900 Limit=0000FFFF Flags=9B USE32

-DL 4 C
#0004 Base=00044D60 Limit=000000FF Flags=92 USE32
#000C Base=00400000 Limit=00345FFF Flags=9A USE32
```

```
-DI
#0000 INTGATE  0064:00001FF0  Flags=8E TYPE=386 DPL=00
#0001 INTGATE  0064:0000201F  Flags=8E TYPE=386 DPL=00
#0002 INTGATE  0064:00005A79  Flags=8E TYPE=386 DPL=00
#0003 INTGATE  0064:0000208D  Flags=8E TYPE=386 DPL=00
#0004 INTGATE  0064:000020C6  Flags=8E TYPE=386 DPL=00
#0005 INTGATE  0064:000020F5  Flags=8E TYPE=386 DPL=00
#0006 INTGATE  0064:00002124  Flags=8E TYPE=386 DPL=00
#0007 INTGATE  0064:00005C08  Flags=8E TYPE=386 DPL=00
#0008 INTGATE  0064:00002182  Flags=8E TYPE=386 DPL=00
#0009 INTGATE  0064:000021B1  Flags=8E TYPE=386 DPL=00
#000A INTGATE  0064:000021E0  Flags=8E TYPE=386 DPL=00
#000B INTGATE  0064:0000220F  Flags=8E TYPE=386 DPL=00
#000C INTGATE  0064:0000223E  Flags=8E TYPE=386 DPL=00
#000D INTGATE  0064:0000226D  Flags=8E TYPE=386 DPL=00
#000E INTGATE  0064:0000229C  Flags=8E TYPE=386 DPL=00
#000F INTGATE  0064:00005A79  Flags=8E TYPE=386 DPL=00
```

3.7 DTSS, DTSS16, and DTSS32 Commands — Display Task State Segment

Syntax:

```
DTSS [selector]
DTSS16 address
DTSS32 address
```

Description:

The DTSS commands display task state segments. Most DOS application programs do not use task state segments, but embedded applications that are prototyped under DOS may use TSSs. See the Intel manual, *80386 Programmer's Reference Manual*, for a description of the contents and use of a task state segment.

The DTSS command displays the contents of the task state segment specified by the segment selector. The descriptor corresponding to the selector must be a 386 or a 286 TSS system segment. If no selector is given, the selector in the task register (TR) is assumed.

The DTSS16 and DTSS32 commands assume the address specified with the command is the address of a TSS data structure. The DTSS16 command displays a 286 TSS, and the DTSS32 displays a 386 TSS.

Example:

```
-DTSS 80
TSS address = 0080:00000000
EAX=00000000  EBX=00000000  ECX=00000000  EDX=00000000
ESI=00000000  EDI=00000000  EBP=00000000  ESP=00000000
DS=0000  SS=0000  ES=0000  FS=0000  GS=0000
CS:EIP=0000:00000000  EFLAGS=00000000
SS:ESP(0)=0120:00000100  SS:ESP(1)=0000:00000000
SS:ESP(2)=0000:00000000  LDTR=0028  CR3=003D5000
BACKLNK=0000  TBIT=0  IOMAP=0000

-DTSS32 88:0
TSS address = 0088:00000000
EAX=00000000  EBX=00000000  ECX=00000000  EDX=00000000
ESI=00000000  EDI=00000000  EBP=00000000  ESP=00000000
DS=0000  SS=0000  ES=0000  FS=0000  GS=0000
CS:EIP=0000:00000000  EFLAGS=00000000
SS:ESP(0)=0120:00000100  SS:ESP(1)=0000:00000000
SS:ESP(2)=0000:00000000  LDTR=0028  CR3=003D5000
BACKLNK=0000  TBIT=0  IOMAP=0000
```

3.8 E, EB, ED, and EW Commands — Enter (Change) Memory

Syntax:

```
E address value(s)
EB address value(s)
ED address value(s)
EW address value(s)
```

Description:

The enter commands change memory locations. The E and EB commands are synonymous and are used to change memory one byte at a time. The EW command changes memory one word at a time, and the ED command operates on doublewords.

The operands to the enter commands are the address of the memory to modify, followed by a list of one or more values to enter at that memory location. If no segment selector is given with the address, the segment pointed to by DS is assumed.

The E and EB commands accept character strings as well as hexadecimal values to enter into memory. Each character in the strings is stored in memory as a separate byte.

Example:

```
-DB buf  buf+F
0014:00000100  00 00 00 00 00 00 00 00-00 00 00 00 00 00 00 00 ............

-EW buf  1234
-DB buf  buf+F
0014:00000100  34 12 00 00 00 00 00 00-00 00 00 00 00 00 00 00 4...........

-EB buf  FF 'HELLO' FF
-DB buf  buf+F
0014:00000100  FF 48 45 4C 4C 4F FF 00-00 00 00 00 00 00 00 00 .HELLO

-ED 200 12345678
-DB 200 20F
0014:00000200  78 56 34 12 00 00 00 00-00 00 00 00 00 00 00 00 xV4
```

3.9 F Command — Fill Memory

Syntax:

```
F range value(s)
```

Description:

The fill command initializes a block of memory to a particular value. The command operands to the F command are a memory range, followed by one or more data bytes. The range specifies which memory locations are to be filled. The values must be either byte values or character strings, and are replicated as many times as necessary to fill the specified range. If no segment is specified with the address, the segment pointed to by DS is assumed.

Example:

The command

```
-F 100 1FF 0
```

sets all memory locations from location DS:100 to 1FF, inclusive, to zero.

The command

```
-F 1000 1200 'HELLO'
```

fills locations DS:1000 to 1200, inclusive, with the string 'HELLO' repeated over and over.

3.10 G Command — Go

Syntax:

```
G [=address] [address(es)]
```

Description:

The go command starts a program running. In its simplest form, the G command takes no operands. It starts execution at the instruction pointed to by CS:EIP (the instruction pointer). Control is returned to 386 | DEBUG when one of the conditions described in section 2.8 occurs.

The G command can also transfer control to an arbitrary location in the program. The start address to which control is to be transferred is indicated by preceding the address with an equal sign (=).

The G command also allows temporary breakpoints to be set in a program. Temporary breakpoints are specified by listing, as command operands, the address of one or more instructions where the breakpoints are to be set. Up to four temporary breakpoints can be set at any one time, but the program will run only until the first breakpoint is encountered Any other breakpoints are cleared when 386 | DEBUG regains control. If you want a temporary breakpoint to remain set, you must re-enter it with the next G command.

If no segment selector is specified with either the breakpoint addresses or the start address, then the selector in the CS register is used by default.

Example:

To continue execution at the current CS:EIP:

```
    -G
```

To set a temporary breakpoint at function "rd_line":

```
    -G rd_line
```

To continue execution at 000C:20:

```
    -G =C:20
```

To continue execution at "fatal_err" and set temporary breakpoints at "printf" and "exit":

```
    -G =fatal_err printf exit
```

3.11 H Command — Perform Hex Arithmetic

Syntax:

```
    H value value
```

Description:

The hex arithmetic command provides a hexadecimal calculator in 386 | DEBUG. The command takes two 32-bit hex numbers as operands. It computes the sum of and difference between the two numbers, and the product and quotient, and displays the result in hex. The product and quotient will not be displayed if one of the numbers is zero.

Example:

```
    -h 2a c1
    0000002A + 000000C1 = 000000EB    0000002A - 000000C1 = FFFFFF69
    0000002A * 000000C1 = 00001FAA    0000002A / 000000C1 = 00000000
```

3.12 I Command — Input from Port

Syntax:

```
I port
```

Description:

The input command is used to read a byte value from an input port. The single operand to the command is the number of the input port to read. 386 | DEBUG reads the port and displays the value read in hexadecimal.

Example:

```
-I 0
Port 0000 = 00
```

3.13 K and KA Commands — Stack Trace

Syntax:

```
K [arg_count]

KA
```

Description:

The stack trace commands display the current procedure call stack. The first line of the display shows the current procedure and offset within the procedure. Succeeding lines of the display trace the call back to the top level procedure, one line per procedure call. For example, the second line shows the procedure which called the current procedure, and the address of the instruction that will be executed when the current procedure returns.

Note that the stack trace commands rely on a standard stack frame being set up for each procedure. Many compilers optimize procedures which have no local variables by not setting up a stack frame. If this occurs, the stack trace commands will not display complete information — one or more of the links in the trace will be missing. To guarantee that the stack trace command gives complete information, compiler switches should be used to force a standard stack frame to be set up for every procedure.

For the MetaWare High C or Professional Pascal compilers, put the statement "pragma off(optimize_fp);" in a profile file or at the top of each source file.

For the Microway NDP C-386 and NDP Fortran-386 compilers, use the "-ga" command line switch when you compile the program.

For the Watcom C-386 compiler, use the switch "/3S" when you compile the program.

The K stack trace command does not attempt to determine how many arguments are passed to each procedure. An optional number can be given as a command operand, specifying the number of arguments to list for each procedure. If no operand is given, the K command displays no procedure arguments. Note that procedure arguments are displayed as 32-bit values when debugging protected mode programs, and as 16-bit values when debugging real mode programs.

The KA stack trace command with arguments attempts to automatically determine how many arguments each procedure has, so that it can display the correct number of arguments to each procedure. Since this command decides how many arguments to display automatically, it takes no command operands. Note that the KA command relies on the calling procedure popping arguments off the stack immediately after the procedure call. This command should not be used with languages (such as Pascal) which use the convention that the called procedure pops its arguments before returning. In addition, any compiler optimizations that delay popping of arguments should be disabled when using the KA command. For the MetaWare High C compiler, use the statement "pragma off(postpone_callee_pops);" in a profile file or at the top of each source code file.

In order to work correctly, the K and KA commands must know the memory model of the program being debugged. The memory model is specified with the -SMALL, -COMPACT, -MEDIUM, or -LARGE command line switches, or with the MS, MC, MM, or ML commands.

Example:

```
-K
get_line
scan_line+0B5
read_file+012C
main+03A

-K 2
get_line (000000001,0002AF44)
scan_line+0B5 (0000C252,FFFFFFFF)
read_file+012C (00000000,00000000)
main+03A (00000228,00000003)

-KA
get_line (000000001,0002AF44)
scan_line+0B5 (0000C252)
read_file+012C (00000000,00000000,0000A400,00000002)
main+03A (00000228,00000003)
```

3.14 M Command — Move Memory

Syntax:

`M` *`range address`*

Description:

The move memory command copies a block of memory from one location to another. The command requires three operands. The first two operands specify the address range of the block to be copied. The third operand specifies the location to which the block is to be copied. The source and destination blocks may not overlap. If they do, the contents of the destination block will be unpredictable. If no segment selector is specified with the start address or the destination address, the segment pointed to by DS is assumed.

Example:

The command

```
-M 100 1FF 200
```

moves locations DS:100 through 1FF to locations DS:200 through 2FF.

The command

```
-M buf1  buf1+20  buf2
```

copies the first 32 bytes of "buf1" to the beginning of "buf2".

3.15 MC, ML, MM, MS, and M? Commands — Select Memory Model

Syntax:

```
MC
ML
MM
MS
M?
```

Description:

The select memory model commands specify the memory model of the program being debugged. 386 | DEBUG must know this information in order to correctly execute the K and KA (stack trace) commands, and in order to correctly use the * indirection operator. The memory model of a program is determined at the time the program is compiled.

The MS command selects the small memory model (NEAR code and NEAR data pointers). The MC command selects the compact memory model (NEAR code and FAR data pointers). The MM command selects the medium memory model (FAR code and NEAR data pointers). The ML command selects the large memory model (FAR code and FAR data pointers). The default memory model assumed by 386 | DEBUG is small model.

The M? command displays the memory model currently assumed by 386 | DEBUG.

Example:

```
-MM    Select medium model
-ML    Select large model
-M?
Current memory model = LARGE
```

3.16 O Command — Output to Port

Syntax:

```
O port value
```

Description:

The output to port command outputs a data byte to an output port. The command takes two operands. The first operand is the number of the port to which the data byte is to be sent. The second operand is the data byte to write to the port.

Warning: Misuse of this command can crash your system and require a reboot. When using the O command, always make sure that the port number and data byte are valid.

Example:

To output a byte value of FF to port 100:

```
-O 100 FF
```

3.17 P and PQ Commands — Procedure Trace (Single Step Across CALL and INT Instructions)

Syntax:

```
P [=address] [count]
PQ [=address] [count]
```

Description:

The procedure trace commands trace the execution of a program one instruction at a time, while stepping over CALL instructions instead of into the called procedure. These commands are useful when tracing execution through a procedure in which you are only interested in what that procedure does, not what any called procedures do.

The P and PQ commands also step to the next instruction after an INT instruction, rather than to two instructions after the INT as the T and TQ do.

The P command has a function similar to the T command except that it traces across CALL instructions instead of into the called procedure. Likewise, the PQ command traces quietly, as does the TQ command, except that it traces across CALL instructions. Section 3.26 describes the T and TQ commands.

Example:

Trace three instructions at CS:EIP:

```
-PT 3
```

Trace ten instructions quietly:

```
-PQ A
```

3.18 PI and PL Commands — Display Paging Information

Syntax:

```
PI address
PL linaddr
```

Description:

The display paging information commands show the contents of the page table entry for a specific address, and break apart the page table entry into some of its contents (the physical address of the memory page, the access rights for the page, and whether the page has been referenced by the program). See the Intel manual, *80386 Programmer's Reference Manual,* for a complete description of page tables and page table entries.

The PI command takes a normal segment:offset address. If no segment is specified, the segment pointed to by DS is assumed.

The PL command takes a linear address. A linear address is formed by adding the offset within a segment to the base address of the segment.

Example:

```
-pi 100
Linear address for 0014:00000100 = 00468100
Page table entry for linear address 00468000=003B4267
Physical base addr=003B4000 access=rd/wr usage=write privilege=user

-dl 14 14
#0014  Base=00468000  Limit=0029BFFF  Flags=92  USE32
-pl 468000
Page table entry for linear address 00468000=003B4267
Physical base addr=003B4000 access=rd/wr usage=write privilege=user
```

3.19 PROT Command — Assume Protected Mode

Syntax:

```
PROT
```

Description:

The PROT command tells 386 | DEBUG to treat all program addresses as protected mode addresses (see section 2.9). 386 | DEBUG assumes protected mode addresses for protected mode programs, and real mode addresses for real mode programs.

When debugging mixed real and protected mode programs, you may occasionally want to look at protected mode code or data while the program is running in real mode, or vice versa. The PROT and REAL commands give you this ability.

Example:

```
PROT
```

3.20 Q Command — Quit

Syntax:

```
Q
```

Description:

The quit command is used to exit 386 | DEBUG. Use it to end a debugging session and to go back to DOS in order to run other programs.

Example:

```
-Q
C>  (DOS prompt)
```

3.21 R Command — Display or Change Registers

Syntax:

```
R [register [value]]
```

register and *value* are printed in italics.

Description:

The register command displays and changes the contents of internal 80386 registers. The command has three different forms. If no operands are given with the R command, then all of the general purpose 80386 registers display on the screen. The register display looks like this:

```
-R
EAX=00000000  EBX=00000000  ECX=00000000  EDX=00000000
ESI=00000000  EDI=00000000  EBP=00000000  ESP=00001FFE
DS=0014  SS=0014  ES=0014  ES=0014  GS=0014
CS:EIP=000C:0000200  EFLAGS=00000202 NV  UP  EI  PL  NZ  NA  PO  NC
000C:0000200 B409  MOV AH,09
```

The first line shows the four data registers EAX, EBX, ECX, and EDX. The second line shows the four address registers ESI, EDI, EBP, and ESP. The third line shows five of the six segment registers DS, SS, ES, FS, and GS. The fourth line shows the address of the next instruction to be executed (CS:EIP), and the contents of the flag register, EFLAGS. EFLAGS is shown both as a hexadecimal value and with mnemonics for the flag bits of most interest. The following mnemonics indicate if a particular flag bit is on or off:

TABLE 3-1
FLAG MNEMONICS

Bit Number	Flag	Off	On
17	Virtual 8086 Mode	blank	VM
11	Overflow	NV	OV
10	Direction	UP	DN
9	Interrupt Enable	DI	EI
7	Sign	PL	NG
6	Zero	NZ	ZR
4	Auxiliary Carry	NA	AC
2	Parity	PO	PE
0	Carry	NC	CY

The second form of the R command displays the contents of a single 80386 register. In this form, the command operand is the name of the register to be displayed. Valid register names are:

32-bit data registers:	EAX, EBX, ECX, and EDX
16-bit data registers:	AX, BX, CX, and DX
8-bit data registers:	AL, BL, CL, DL, AH, BH, CH, and DH
32-bit address registers:	ESI, EDI, EBP, and ESP
16-bit address registers:	SI, DI, BP, and SP
Segment registers:	CS, DS, SS, ES, FS, and GS
Instruction pointer:	EIP and IP
Control registers:	CR0, CR2, and CR3
Debug registers:	DR0, DR1, DR2, DR3, DR6, and DR7
Test registers:	TR6 and TR7

The third form of the R command changes the contents of an 80386 register. In this form of the R command, two operands are given. The first operand is the name of the register to be changed. The second operand is a value to be loaded into the register.

Note that if you gain control in 386 | DEBUG by typing CTRL/C while a protected mode program is running, 386 | DEBUG will not allow register values to be modified. Breakpoints and watchpoints can still be set as usual after a CTRL/C.

Example:

```
-R ESI
ESI=00000000
-R ESI 123
-R ESI
ESI=00000123
```

3.22 R67, R67D, R67S, and R87 Commands — Display Floating Point Coprocessor Registers

Syntax:

```
R67
R67D
R67S
R87
```

Description:

The R67 and R67D commands display in double precision form the floating point registers in a Weitek 1167, 3167, or 4167 floating point coprocessor.

The R67S command displays in single precision form the floating point registers in a Weitek 1167, 3167, or 4167 floating point coprocessor.

The R87 command displays floating point registers from an 80287, 80387, or compatible floating point coprocessor.

Example:

```
-R87
ST(0)=0.0000000000E+00    0000 0000000000000000  Tag=11 (Empty)
ST(1)=0.0000000000E+00    0000 0000000000000000  Tag=11 (Empty)
ST(2)=0.0000000000E+00    0000 0000000000000000  Tag=11 (Empty)
ST(3)=0.0000000000E+00    0000 0000000000000000  Tag=11 (Empty)
ST(4)=0.0000000000E+00    0000 0000000000000000  Tag=11 (Empty)
ST(5)=5.2581787109E-01   3FFE 869C00000008000D  Tag=11 (Empty)
ST(6)=1.0000000000E+00   3FFF 8000000000000000  Tag=11 (Empty)
ST(7)=2.5000000000E+04   400D C35000000003F3A0  Tag=11 (Empty)
Control Word=037F  Status Word=4124  Tag Word=FFFF

-R67
WD0 =0.00000000E+00   Hex=0000000000000000
WD2 =2.49989997E+04   Hex=40D869BFFACCF4D3
WD4 =1.60012805E-09   Hex=3E1B7D7004C31321
WD6 =-4.79770300E+03   Hex=C0B2BDB3F8129D59
WD8 =7.85398163E-01   Hex=3FE921FB54442D18
WD10=1.78390320E+04   Hex=40D16BC20C49BA5E
WD12=0.00000000E+00   Hex=0000000000000000
WD14=0.00000000E+00   Hex=0000000000000000
WD16=0.00000000E+00   Hex=0000000000000000
WD18=0.00000000E+00   Hex=0000000000000000
WD20=0.00000000E+00   Hex=0000000000000000
WD22=0.00000000E+00   Hex=0000000000000000
WD24=0.00000000E+00   Hex=0000000000000000
WD26=0.00000000E+00   Hex=0000000000000000
WD28=0.00000000E+00   Hex=0000000000000000
WD30=0.00000000E+00   Hex=0000000000000000
Mode=03 ExcMask=FF CCode=80 AccExc=20

-R67s
WS0 =0.000000E+00   Hex=00000000       WS1 =0.000000E+00   Hex=00000000
WS2 =6.762908E+00   Hex=40D869BF       WS3 =-5.320971E+35   Hex=FACCF4D3
WS4 =1.518457E-01   Hex=3E1B7D70       WS5 =4.586185E-36   Hex=04C31321
WS6 =-5.585657E+00   Hex=C0B2BDB3       WS7 =-1.189479E+34   Hex=F8129D59
WS8 =1.821350E+00   Hex=3FE921FB       WS9 =3.370281E+12   Hex=54442D18
WS10=6.544404E+00   Hex=40D16BC2       WS11=1.554056E-31   Hex=0C49BA5E
WS12=0.000000E+00   Hex=00000000       WS13=0.000000E+00   Hex=00000000
WS14=0.000000E+00   Hex=00000000       WS15=0.000000E+00   Hex=00000000
WS16=0.000000E+00   Hex=00000000       WS17=0.000000E+00   Hex=00000000
WS18=0.000000E+00   Hex=00000000       WS19=0.000000E+00   Hex=00000000
WS20=0.000000E+00   Hex=00000000       WS21=0.000000E+00   Hex=00000000
WS22=0.000000E+00   Hex=00000000       WS23=0.000000E+00   Hex=00000000
WS24=0.000000E+00   Hex=00000000       WS25=0.000000E+00   Hex=00000000
WS26=0.000000E+00   Hex=00000000       WS27=0.000000E+00   Hex=00000000
WS28=0.000000E+00   Hex=00000000       WS29=0.000000E+00   Hex=00000000
WS30=0.000000E+00   Hex=00000000       WS31=0.000000E+00   Hex=00000000
Mode=03 ExcMask=FF CCode=80 AccExc=20
```

3.23 REAL Command — Assume Real Mode Addressing

Syntax:

```
REAL
```

Description:

The REAL command tells 386|DEBUG to treat all program addresses as real mode addresses (see section 2.9). 386|DEBUG assumes protected mode addresses for protected mode programs, and real mode addresses for real mode programs.

When debugging mixed real and protected mode programs, you may occasionally want to look at protected mode code or data while the program is running in real mode, or vice versa. The PROT and REAL commands give you this ability.

Example:

```
REAL
```

3.24 RX Command — Display Extended Registers

Syntax:

```
RX
```

Description:

The display extended registers command displays all internal registers of the 80386 CPU. Like the R command, RX displays the general registers (EAX, EBX, etc.), the segment registers (DS, CS, etc.), and the flags. In addition, the RX command also displays the following special 80386 registers:

☛ The debug registers DR0, DR1, DR2, DR3, DR6, and DR7;

☛ The control registers CR0, CR2, and CR3;

- The test registers TR6 and TR7;
- The TR, GDTR, LDTR, and IDTR registers.

Example:

```
-RX
EAX=00000000  EBX=00000000  ECX=00000000  EDX=00000000
ESI=00000000  EDI=00000000  EBP=00000000  ESP=00001FFE
DS=0014  SS=0014  ES=0014  FS=0014  GS=0014
CS:EIP=000C:00000200        NV  UP  EI  PL  NZ  NA  PO  NC
CR0=00000001  CR2=00000000  CR3=0000F000
DR0=00021360  DR1=00000000  DR2=00000000  DR3=00000000
DR6=0000E00F  DR7=00000003
TR6=00000000  TR7=00000000
GDTbase=00011D96 GDTlimit=002F  IDTbase=00011EF4 IDTlimit=07FF
LDT=0028  TR=0000
```

3.25 S Command — Search Memory for String

Syntax:

```
S range values
```

Description:

The search command searches a block of memory for the occurrence of a string of data bytes. The first two command operands specify the address range of the memory block to be searched. The remaining operands specify the string of bytes for which memory is to be searched. The values may be given as separate bytes or as character strings. If no segment selector is given with the start address, the segment pointed to by DS is assumed.

The S command searches the entire specified range for each occurrence of the specified byte or string of bytes. Each time the specified values are encountered, the address of the first byte in the value string is printed out.

Example:

```
-DB 0  1F
0014:00000000 B4 09 BA 10 00 00 00 CD-21 66 B8 00 4C CD 21 00 4.:....M!f8.LM!.
0014:00000000 48 65 6C 6F 20 77 6F-72 6C 64 21 21 21 21 21 Hello world!!!!!
```

```
-S 0 1F CD 21
0014:00000007
0014:0000000D
-S DS:0 1F 'HELLO'
-S DS:0 1F 'Hello'
0014:00000010
-S 14:0 1F '!'
0014:00000008
0014:0000000E
0014:0000001B
0014:0000001C
0014:0000001D
0014:0000001E
0014:0000001F
```

3.26 T and TQ Commands — Trace (Single-Step)

Syntax:

```
T  [=address] [count]
TQ [=address] [count]
```

Description:

The trace commands trace the execution of a program one instruction at a time. In its simplest form, the T command takes no operands. It executes one 80386 instruction and then displays the 80386 registers on the screen. The registers display in the same form as the R command. The instruction addressed by instruction pointer CS:EIP is the instruction which is executed.

If a count is given as an operand to the T command, then this count specifies the number of instructions to be executed before stopping. The 80386 registers display after each instruction is executed. This form of the T command is useful for tracing a program without having to keep re-entering the T command. The character * can be used to specify an infinite count. If this value is given, instructions will be traced until a processor exception occurs or the program terminates.

The TQ command (trace quietly) is the same as the T command, except that the registers are only printed out after the specified number of instructions are traced or a processor exception occurs, instead of after every instruction traced. When 386|DEBUG gains control after a TQ instruction, it prints out the number of instructions that were traced.

A second option to the T and TQ commands allows the start address for execution to be specified. Simply enter an equal sign (=) followed by the address, to begin execution. If no segment selector is specified for the start address, then the selector in the CS register will be used by default.

When the instruction to be traced is a software interrupt (INT) instruction, two instructions rather than one are actually traced, due to the 80386 architecture. The T instruction prints the message "Stepped two instructions to . . ." as a reminder after tracing over an INT instruction. The P and PQ commands can be used to trace only one instruction after an INT instruction.

Example:

Trace five instructions at CS:EIP:

```
-T 5
```

Trace ten instructions at CS:100, only display the registers after the tenth instruction:

```
-TQ =100 A
```

Trace instructions until a processor exception occurs or the program terminates:

```
-TQ *
```

3.27 U, U16, U32 Commands — Unassemble (Disassemble) a Block of Memory

Syntax:

```
U [range]
U16 [range]
U32 [range]
```

Description:

The U, U16, and U32 commands disassemble a block of memory and display its contents as 80386 instructions. These commands take two optional operands, which specify the range of memory to be unassembled. If no operands are specified, 32 bytes will be unassembled, beginning one byte past the last byte unassembled the last time the command was executed. If only a start address is specified, 32 bytes will be unassembled, beginning at the start address. If both a start address and an end address are specified, the entire block will be unassembled. If no segment selector is specified for the start address to unassemble, then the selector in the CS register will be used by default.

For each instruction unassembled, 386 | DEBUG displays a line with the instruction's address, the hexadecimal values for the opcode bytes, and the assembly language statement for the instruction and its operands. Operand size is specified with the PTR operator where necessary, and segment overrides are indicated with the : operator.

Before unassembling the instruction at the start address, the offset of the instruction from the nearest previous symbol is displayed. If the unassemble command crosses into a new function while unassembling a block of instructions, the name of the new function is displayed.

In order to correctly unassemble a block of code, 386 | DEBUG must know whether the default operand size of the code segment descriptor is 16 bits or 32 bits.

If the U16 or U32 forms of the unassemble command are used, 386 | DEBUG assumes a default operand and address size based on the name of the command. U16 instructs 386 | DEBUG to assume a default operand and address width of 16 bits, while U32 causes it to assume a default width of 32 bits.

The U form of the unassemble command does not specify a default operand or address size, and 386 | DEBUG will infer one using the following logic:

- ☛ If the program is running in real mode, a default size of 16 bits is assumed. This is a requirement of the 80386 architecture.

☛ If the program is running in protected mode, 386|DEBUG uses the segment selector for the address being unassembled to make its size assumption. It looks up the selector in the appropriate descriptor table and extracts the operand size information directly from the table entry.

In most cases, the U form of the unassemble command suffices. The U16 and U32 commands are sometimes necessary when writing systems code, or when unassembling code in a data segment (for example, disassembling DOS code in the USE32 data segment that maps the low one megabyte of physical memory).

Example:

Example unassembly for real mode:

```
-u MAIN  MAIN+B
MAIN:
4E46:00000000 B84C4E MOV   AX,4E4C
4E46:00000003 8ED8   MOV   DS,AX
4E46:00000005 66BA1F000000 MOV   EDX,0000001F
4E46:0000000B E81900 CALL  0027
```

Example unassembly for protected mode:

```
-u 2e40 2e48
SCAN+056:
000C:00002E40 0400   ADD   AL,00
000C:00002E42 00E8   ADD   AL,CH
000C:00002E44 A2070000B4   MOV   [B4000007],AL
```

Example of forcing a 32-bit unassembly:

```
-u32 SCAN+6f  SCAN+79
SCAN to 6F:
000C:00002A59 6650   PUSH  AX
000C:00002A5B 8D1DE9000000 LEA   EBX,[000000E9]
000C:00002A61 E8840B0000   CALL  000035EA
```

Example of unassembling some 16-bit code while in 32-bit protected mode (this code is part of the ROM BIOS):

```
-u16 34:f000b f0010
0034:000F000B 8BF0   MOV   SI,AX
0034:000F000D B84000 MOV   AX,0040
0034:000F0010 8ED8   MOV   DS,AX
```

3.28 WC, WD, WE, WL, and WP Commands — Watchpoint Control

Syntax:

```
WC watchpts
WC *
WD watchpts
WD *
WE watchpts
WE *
WL
WP address datalen [r|w]
```

Description:

The watchpoint control commands set, clear, enable, disable, and list data watchpoints. Data watchpoints cause 386 | DEBUG to stop execution of the application immediately after execution of an instruction that reads or writes a specific memory location. When a data watchpoint occurs, 386 | DEBUG displays the memory location that is accessed, and the current register contents, and then prompts for a command. Data watchpoints can be useful for finding bugs which cause code or data locations in the program to be corrupted.

The WC command clears watchpoints. It takes as arguments either a list of watchpoint numbers, or the special character *, which is a shorthand for all watchpoints. Once a watchpoint has been cleared, it will no longer be listed by the WL command and cannot be enabled with the WE command. If the watchpoint is needed again after being cleared, it must be reset with the WP command.

The WD and WE commands disable and enable watchpoints. They take as arguments either a list of watchpoint numbers, or the special character *, which is a shorthand for all watchpoints. The WD command is used to temporarily disable watchpoints that are not desired to be active. The WE command is used to enable watchpoints that have been previously disabled with the WD command.

The WL command lists watchpoints that have been set with the WP command. Each watchpoint is identified by a number that is assigned by 386 | DEBUG. For each watchpoint, the WL command lists its watchpoint number, the address of the location the watchpoint is set on, and whether it is a write-only or a read/write watchpoint. In addition, if the watchpoint has been disabled, the WL command will print "***disabled***" following the watchpoint information.

The WP command sets watchpoints. The first command operand is the address of location to be watched. The second operand gives the data size of the expected access (one, two, or four bytes). If the wrong data size is used, the hardware will not detect an access to the memory location. The third operand is optional and specifies whether the watchpoint is to occur only on write accesses, or for any type of access (read or write). The character "w" is used to specify a write-only watchpoint, and the character "r" is used to specify a read/write watchpoint. If no third operand is given, a write-only watchpoint is set.

Example:

```
-WP buf+21 1
-WP bufp 4 r
-WP errf 2 w
-WL
0 BUF+021 datalen=1 write only
1 BUFP datalen=4 read/write
2 ERRF datalen=2 write only
-WD 1
-WL
0 BUF+021 datalen=1 write only
1 BUFP datalen=4 read/write  ***disabled***
2 ERRF datalen=2 write only
-WE *
-WC 0 2
-WL
1 BUFP datalen=4 read/write
```

3.29 X Command — Display Symbol Table

Syntax:

```
X [symbol]
```

Description:

The display symbol table command displays the public symbols and their values for the program being debugged. If no command operand is given with the X command, the entire symbol table is displayed. If a string value is given as a command operand, all symbols whose names begin with the specified string are displayed. CTRL/S can be used to stop scrolling, and CTRL/C to return to the prompt.

Example:

```
-X ma
MAIN = 0000000A
MAKE_PTR = 0000032C
MARK_POS = 000045B0

-X mak
MAKE_PTR = 0000032C
```

3.30 XR Command — Relocate Symbol Table

Syntax:

```
XR old_sel new_sel
```

Description:

Use the XR command to inform 386 | DEBUG that the symbol table applies to code and data in segments other than the default code and data segments of 000Ch and 0014h. This command allows symbolic debugging of separate add-in drivers or overlays that are loaded by the main program at runtime.

Use the -SYMFILE switch when starting 386 | DEBUG to load the symbol table for the add-in driver rather than the main program. After the main program has loaded the driver, use the XR command to relocate the symbol table from segments 000Ch and 0014h to the segments used for the add-in driver.

Please see section 2.5 for more information on debugging with an alternate symbol table.

Example:

```
-XR c 7c
-XR 14 84
```

3.31 XS Command — Display Segment Names

Syntax:

```
XS
```

Description:

The display segment names command displays the name, the segment selector value (the values that are loaded into segment registers to address the segments), and the size in bytes of each of the program's segments. For protected mode programs, the linker constructs a single large program segment, and assigns the segment name FLAT_CODE to selector 000C, and the name FLAT_DATA to selector 0014. Therefore, the XS command will always show the same information for protected mode programs. For real mode programs, the segments and group names are shown as they are defined in the source code, and the segment values are the paragraph base address of the segment or group.

Example:

For a protected mode program:

```
-XS
FLAT_CODE                000C  Size = 0001A800
FLAT_DATA                0014  Size = 0001A800
```

For a real mode program:

```
-XS
_BSS                      2E76  Size = 00000200
_CODE                     2350  Size = 0000B260
_DATA                     2E96  Size = 000039E4
DGROUP                    2E76  Size = 00003BE4
```

3.32 XW Command — Locate Symbol

Syntax:

```
XW address
```

Description:

The locate symbol command finds the nearest previous symbol to a specific address in a program. The single command operand is the program address to be looked up in the symbol table. The nearest previous symbol and the offset from the symbol's address to the specified address is displayed. If the specified address is exactly equal to the symbol's address, then the symbol is displayed with no offset.

Example:

```
-XW 400
CHK_ERR+01C

-XW dgroup:30
DATBUF
```

3.33 ? Command — On Line Help

Syntax:

```
? [character]
```

Description:

The ? command obtains online help with 386 | DEBUG command formats. The help screen lists each command, shows the operands to each command, and gives a one-line description of the command.

If a single character prefix is given, only the commands that start with that character are listed.

Example:

```
-? T
    T  [=address] [count]   Trace (single-step)
    TQ [=address] [count]   Trace quietly
```

386 | DEBUG Command Line

```
386DEBUG [debugswitches] programname arguments
```

debugswitches	Optional ; override the default operation of 386 | DEBUG
programname	Name of .EXP, .EXE, or .REX file to be debugged
arguments	Parameters passed to program being debugged

386 | DEBUG Commands:

BC *breakpoints* | *	Clear breakpoints
BD *breakpoints* | *	Disable breakpoints
BE *breakpoints* | *	Enable breakpoints
BL	List all breakpoints
BP *address*	Set breakpoint
C *range address*	Compare memory
COM1	Redirect I/O to serial channel #1
COM2	Redirect I/O to serial channel #2
CON	Return I/O to console
D [*range*]	Dump memory
DA [*range*]	Dump memory in ASCII
DB [*range*]	Dump memory as hex bytes
DD [*range*]	Dump memory as hex double words
DF [*range*]	Dump memory as 4 byte floats
DW [*range*]	Dump memory as hex words
DG [*range*]	Dump GDT
DI [*range*]	Dump IDT
DL [*range*]	Dump LDT
DQ [*range*]	Dump memory as 8 byte floats
DS [*range*]	Dump memory as 4 byte floats
DT [*range*]	Dump memory as 10 byte floats

DTSS [*selector*]	Dump TSS specified by TR or selector
DTSS16 *address*	Dump 286 TSS at sel:offset address
DTSS32 *address*	Dump 386 TSS at sel:offset address
E *address value(s)*	Enter (change) memory by bytes
EB *address value(s)*	Enter (change) memory by bytes
ED *address value(s)*	Enter (change) memory by double words
EW *address value(s)*	Enter (change) memory by words
F *range value(s)*	Fill memory
G [=*address*] [*address(es)*]	Go (and set breakpoints)
H *value value*	Hex arithmetic
I *port*	Input from port
K [*arg_count*]	Display function call stack
KA	Display function call stack with args
M *range address*	Move memory
MC	Use COMPACT memory model
ML	Use LARGE memory model
MM	Use MEDIUM memory model
MS	Use SMALL memory model
M?	Show current memory model
O *port value*	Output to port
P [=*address*] [*count*]	Trace (skipping CALL instrs.)
PI *address*	Show paging info for address
PL *linaddr*	Show paging info for linear addr
PQ [=*address*] [count]	Assume protected mode addresses
PROT	Trace quietly (skipping CALL instrs.)
Q	Quit
R [*register* [*value*]]	Display or change registers
R87	Display 1167/3167/4167 registers
R67[D]	Display 1167/3167/4167 registers
R87	Display 80287/80387 registers
REAL	Assume real mode addresses
RX	Display extended registers
S *range values*	Search memory for string
T [=*address*] [*count*]	Trace (single-step)
TQ [=*address*] [*count*]	Trace quietly
U [*range*]	Unassemble memory
U16 [*range*]	Unassemble memory in USE16 segment
U32 [*range*]	Unassemble memory in USE32 segment
WC *watchpoints* | *	Clear watchpoints

`WD` *watchpoints* | *	Disable watchpoints
`WE` *watchpoints* | *	Enable watchpoints
`WL`	List all watchpoints
`WP` *address datalen* `[r|w]`	Set watchpoint
`X [`*symbol*`]`	Display symbol table
`XR` *old_sel new_sel*	Relocate symbols to another selector
`XS`	Display segment names
`XW` *address*	Locate symbol at address
`? [`*char*`]`	Display debugger commands

Expression Formats:

Values	`12A`	Hexadecimal number
	`'ABC'`	String
	`AL`	Contents of a register
	`F5+AA`	Addition
	`FF-12`	Subtraction
Addresses	`12A`	Offset
	`main`	Symbol
	`CS:145`	Segment register override
	`8:145`	Selector override
	`ESP`	Indirect through a register
	`SS:ESP`	Indirect through a register with segment override
	`buf+10`	Addition
	`EBP-10`	Subtraction
Range	`buf  buf+FF`	Simple range
	`CS:100 1FF`	Range with segment override
	`14:100 1FF`	Range with selector override

Error Messages

This appendix lists 386|DEBUG errors, their causes, and how to correct them. The error messages are divided into two sections. The first section lists errors that can occur when 386|DEBUG attempts to load your program before the first command prompt is displayed. The second section lists errors that can occur when commands are entered. The error messages are listed in alphabetical order within each section.

B.1 Program Load Errors

Error:	`? Can't open executable file: `*`filename`*
Cause:	An attempt has been made to debug a nonexistent .EXP, .EXE, or .REX file.
Solution:	1) Correct the spelling of the name of the .EXP file, or 2) Give the correct directory name in which the .EXP file resides, or 3) Create the .EXP file with 386|LINK.

Error:	`? Error reading file: `*`filename`*
Cause:	The .EXP file is damaged.
Solution:	Rebuild the .EXP file, making sure there are no link errors.

Error:	`? Insufficient memory to load program`
Cause:	Your program is larger than the available memory.
Solution:	1) Shrink your program, or 2) Purchase more memory, or 3) Remove memory resident programs from your system.

Error:	`? Load error`
Cause:	An unknown error occurred when MS-DOS attempted to load a real mode .EXE file.
Solution:	Reboot your system.

Error:	`? Missing file name`
Cause:	An attempt has been made to run 386|DEBUG without specifying a program file to be debugged.
Solution:	Give the name of an .EXP file containing a program to be debugged.

Error:	`? Not an executable file:` *`filename`*
Cause:	The file is not an .EXP, .EXE, or .REX format file.

B.2 Command Errors

Error:	`? Bad command operand`
Cause:	An operand to a command is ill-formed. For example:

`1G`	(Illegal hexadecimal digit)
`1+`	(Missing right operand to +)
`ABC`	(Missing ending quote)

Solution: Correct the operand, and re-enter the command.

Error: `? Can't alter registers after CTRL/C in protected mode`

Cause: An attempt has been made to modify one of the 80386 registers after getting control with a CTRL/C when the program being debugged was executing in protected mode. This is not permitted.

Error: `? Extra characters at end of line`

Cause: After the last operand of a command, more characters were found on the line.

Solution: Remove the extra characters from the line, and re-enter the command.

Error: `? Invalid address:` *`segment:offset`*

Cause: An address which either has an invalid segment selector value or an offset beyond the segment limit has been specified.

`Error:` `? Missing required command operand`

Cause: At least one operand required by the command was not given.

Solution: Use the help (?) command to determine the required command format.

`Error:` `? Only` *`count`* `bytes could actually be entered`

Cause: Fewer bytes than requested were actually written into memory by one of the enter commands (E, EB, EW, ED), because the end of the segment was reached.

`Error:` `? Only` *`count`* `bytes were actually filled`

Cause: Fewer bytes than requested were actually written into memory by the fill (F) command, because the end of the segment was reached.

`Error:` `? Segment selector:` *`value`* `not readable`

Cause: The specified segment cannot be read.

Solution: Use another segment that maps the same memory to read the data.

`Error:` `? Segment selector:` *`value`* `not writable`

Cause: The specified segment cannot be written.

Solution: Use another segment that maps the same memory to write the data.

Error:	`? Unknown command`
Cause:	An illegal command name was given to 386 I DEBUG.
Solution:	Correct the spelling of the command name. Please see Appendix A for a list of valid commands.

Error:	`? Value out of range`
Cause:	A value given as a command operand exceeded the largest value allowed by the command.

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The people who wrote, edited, revised, reviewed, indexed, formatted, polished, and printed this manual were:

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